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ABSTRACT

Meta-analyses of the hypotheses that relationships exist between play and problem solving, and between play and creativity, were conducted. The data set for the meta-analyses included studies designed to investigate the relationship between play and fluency or originality, or between play and problem-solving behavior. The meta-analyses of creativity studies reveal a small but significant relationship between play and originality for familiar objects, but not for unfamiliar objects, and no relationship between play and fluency. The meta-analysis of problem solving studies showed heterogeneous effects for the total sample. About 100 references are listed. Appendixes include a discussion of the meta-analytic procedures used, and tables which present data from the studies analyzed. (PCB)

Play, Problem Solving and Creativity in Young Children

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The idea that play has an important role in human development is an old one going back at least to Darwin's (1859) Origin of Species. Darwin observed that the length of childhood within species seemed to vary directly with the species' place in the evolutionary hierarchy. Darwin's observations led 19th century biologists and psychologists to conclude that infancy and childhood must be significant periods in human life. Children spend much of their time playing, so the next logical step, given the Darwinian analysis, was to attribute a significant role to play as well.

Research on children's play has peaked at three different periods during the 1900s (Fein, 1981). Most recently, since the 1970s, play research has focused on cognitive correlates of play behavior. Piaget's theory that play provides an arena for children to exercise newly acquired cognitive skills has been the primary inspiration for researchers seeking empirical evidence of a relationship between play and cognition. Within this body of literature, play has been suggested to influence creativity and problem solving in one or both of the following manners: 1) through manipulation of an object, the child gains an understanding of that object's properties; this increased understanding contributes to the child's ability to produce variations in actions or uses with that object or to discovery of a problem solution; 2) play results in the generation of a playful attitude, allowing the child freedom to reorganize his/her knowledge.

A large volume of studies exist on play, creativity and problem

solving, which have been the subject of numerous qualitative reviews (e.g., Rubin, Fein & Vandenberg, 1983; Simon & Smith, 1984). Reviewers have generally concluded that there is support for the hypothesis that a relationship exists between play and problem solving (e.g., Smith & Simon, 1984) and play and creativity (e.g., Dansky, 1986).

However, the traditional narrative review can be usefully supplemented by meta-analysis, which is a statistical technique for summarizing the results of independent research (Mullen & Rosenthal, 1985). While a qualitative review generally indicates whether each study had significant findings and the direction of group differences, consistencies among seemingly inconsistent findings are often underestimated. For example, two studies may have equivalent effect sizes (i.e., correlation coefficients) with only one reaching statistical significance due to power differences (Rosenthal & Rosnow, 1985). Meta-analysis can aid in detecting such consistencies in a sample of independent studies. On the other hand, a qualitative review may ignore inconsistencies within a particular body of literature but meta-analysis would result in a small, nonsignificant, effect size. Therefore, meta-analyses were conducted of the hypothesis that a relationship exists between play and problem solving and play and creativity.

The specific questions addressed by these meta-analyses were:

1. Is there a relationship between play and fluency?
2. Is there a relationship between play and originality?

3. Is there a relationship between play and problem solving?

Method

The data set for the meta-analyses was obtained from Psychological Abstracts, review articles and empirical articles on play or the relationship between play, problem solving or creativity. From this survey, 24 articles were located.

Studies were included in the meta-analyses if they were designed to investigate the relationship between play and fluency and/or originality or the relationship between play and problem solving behavior. Summaries of the studies are in Tables 1-3. Descriptions of the tasks used in this literature are in Table 4.

Mullen and Rosenthal's (1985) computer programs for comparing and combining effect sizes and significance levels were used to conduct the meta-analyses. This programs are based upon the method of adding Z's (Rosenthal, 1978), which is widely applicable.

When reported statistics could not be fit into the program requirements, t tests were calculated from the mean, standard deviation and n. When insufficient data were reported, the p value and its associated degrees of freedom were used. Unavailable, nonsignificant p values were set at .50 (one-tailed). Dependent measures from the same study were combined and then input into the overall meta-analysis (Mullen & Rosenthal, 1985). All effect sizes were weighted for sample size. As suggested by Rosenthal and Rosnow (1985), samples were tested for heterogeneity of effect sizes. Heterogeneity indicates the samples do not come

from the same population and suggests the influence of moderator variables. Thus, a meta-analysis on the full sample would be inappropriate. Combined effect sizes, p values and X (test of heterogeneity) for each study are listed in Tables 5-7.

It is likely that many unpublished studies exist in "filedrawers" (Rosenthal, 1978). Mullen & Rosenthal's computer programs provide a failsafe number--the number of null findings it would take to reduce the p value associated with a combined effect size to .05.

Results

Fluency

The sample of fluency studies was homogeneous, $X = 11.70$, $p = .31$. The meta-analysis on fluency studies revealed a small, nonsignificant combined effect size, $r = .06$, $p = .06$. Because the findings of Dansky and Silverman (1973, 1975) indicate that performance on fluency and originality tests may differ along the dimension of familiarity-unfamiliarity, the total sample was also subdivided into studies using familiar objects (same objects used in testing and experimental sessions) vs. unfamiliar objects. Meta-analyses revealed a combined effect size of $r = .03$, $p = .33$, and $r = .05$, $p = .26$, for the familiar objects and unfamiliar objects, respectively.

Originality

The total sample of originality studies was heterogeneous, $X = 42.02$, $p = .0002$. As a result, the sample was subdivided into studies using familiar vs. unfamiliar objects based upon Dansky and Silverman (1973, 1975). The results for unfamiliar toys

remained heterogeneous. A meta-analysis for familiar toys revealed a small but significant combined effect size, r = .22, p = .0000005. It would take 66 null findings to reduce the significance level to .05.

Problem Solving

The total sample of problem solving studies was heterogeneous. As a result, two widely used dependent measures were selected for further analysis: number of spontaneous solvers (those given no hints) and solution time. Both samples were homogeneous.

Results of the meta-analysis for spontaneous solvers revealed a small but significant combined effect size, r = .11, p = .04. With a filedrawer number of 1, the finding is not robust to unpublished null effects, however. Findings of the meta-analysis on the sample of solution times revealed a similarly small, but significant, combined effect size, r = .11, p = .005. The filedrawer number was 1.

CONCLUSIONS

The meta-analyses of creativity studies reveal a small but significant relationship between play and originality for familiar objects, but not unfamiliar objects, and no relationship between play and fluency. Children may form novel associations to familiar objects and/or develop a playful attitude during experimental play sessions, both of which may influence performance on tests of originality.

The meta-analysis of problem solving studies showed heterogeneous effects for the total sample. However, there were very small, but significant, relationships between play and problem

solution time, as well as play and number of spontaneous problem solvers. Qualitative review showed that some evidence exists to support the effect of configurational richness (complexity of designs) on problem solving. That is, a greater number of the children who made numerous complex constructions with the stick and block play materials solved the tasks without hints. However, configurational richness is measured differently by different researchers, preventing one from making any definitive conclusions. Qualitative review also supported meta-analytic findings that use of the solution principle (joining two long sticks) during play is positively related to problem solving.

The weak findings and heterogeneity found among the studies and in the overall meta-analyses suggest that the strongest associations between play and creativity and play and problem solving have yet to be thoroughly investigated. For example, Dansky and Silverman (1973) and Pepler and Ross (1981) found that a broad focus of attention is associated with better task performance. No other studies have looked at use of attention; this seems to be a variable worth examining. Similarly, Hutt and Bhavnani's (1972) study suggested that playfulness may be a style of behavior, and this also warrants investigation. In addition, use of age-appropriate tasks may better reveal any existent linkages between play and problem solving or creativity. Lastly, consideration should be given to what constitutes an appropriate control condition in these studies. For example, drawing is often used as the control experience; however, drawing is a form of symbolic representation and may have the same effect

on creativity or problem solving as play itself.

While the meta-analytic findings were not strong, they did suggest the possibility of a reliable relationship in some domains. Future research incorporating some of the suggested changes may strengthen this conclusion and may, in fact, disclose larger relationships than have been found to date.

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Appendix A. Tasks

1. The Alternative Uses Test is based upon Wallach and Kogan's (1965) measures of creativity, which have been shown to be reliable and have discriminant validity (Cropley & Maslany, 1969; Ward, 1968).

Subject is presented with an object. Subject may look at the object but not handle it. Subject is told "I am going to show you something that can be used in lots of different ways or for lots of different things. I would like you to tell me all the things you can do with it, make with it or use it for."

2. The Lure Retrieval Task: Subject is given sticks of varying lengths and either clamps or blocks (with a hole in each side). Subject is seated at a table. At the other end of the table is a box with a small object inside (marble, chalk). Subject is told the object is a prize in this game, which he may keep if he can figure out a way to get it. Subject is also told he can take as long as he likes to get the object and that there is only one rule: "You cannot get out of your seat." Subject is given hints if he does not make any attempt to get the prize or wishes to leave the experiment.

3. Torrance Tests of Creativity: a) Thinking Creatively with Pictures test (subject must complete 10 pictures from given geometric shapes "in a way no one else will think of" and title each picture); b) Group Construction Task (subjects work together to build a specified object with a limited number of blocks within 15 minutes); c) Thinking Creatively in Action and Movement test (subject must act out solutions to problems).

4. Cincinnati Autonomy Test Battery--Dog and Bone Subtest: Subject must trace as many routes as possible from a dog to its bone through a maze of houses.

Appendix B. Meta-Analytic Procedures.

Meta-analysis is a statistical technique for summarizing the results of independent research (Mullen and Rosenthal, 1985). This tool is useful as a supplement to qualitative literature review, which generally indicate whether each study had significant findings and the direction of group differences but often ignore details of the studies which would reveal any existing consistencies among seemingly inconsistent findings. For example, two studies may have equivalent effect sizes even though only one reaches statistical significance (Rosenthal & Rosnow, 1985). Meta-analysis can detect such consistencies in a sample of independent studies.

Method

Data Sources. The data set for the meta-analyses were obtained from a search of Psychological Abstracts; a survey of review articles on play or the relationship between play, problem solving or creativity (Christie & Johnsen, 1983; Dansky, 1986; Fein, 1981; Pepler, 1982; Rubin, Fein & Vandenberg, 1983; Saltz & Brodie, 1982; Smith & Simon, 1984; Smith & Syddall, 1978; Vandenberg, 1980); as well as articles published in professional journals. From this survey, 24 studies were located.

Studies were included in the meta-analyses if they addressed one or more of the questions of interest or were published or presented at a professional conference. (Most of the unpublished studies were later published or presented; others were unobtainable.)

The sample was divided into three groups: fluency, originality and problem solving studies based upon theoretical and

methodological considerations.

Statistical Analysis. There are two major techniques for summarizing the results of independent research: combining effect sizes (r or d) and combining significance levels (Strube, 1985). Effect size is a ratio of the degree of correlation to the degree of noncorrelation.

Combining results answers the question "Is there overall support for the hypothesis?" (Mullen and Rosenthal, 1985). Thus, effect sizes were combined to calculate the magnitude of the effect (relationship between play and problem solving or creativity) and significance levels were combined to calculate the overall probability level of the sample. Mullen and Rosenthal's (1985) computer programs were employed to perform the meta-analyses. These programs calculate combined effect sizes and significance levels based upon the method of adding Zs, which is routinely applicable (Rosenthal, 1978). Operation of the programs requires input of F(1), t, r, $X^2(1)$, or exact one-tailed p values, as well as the sample size and its associated degrees of freedom, and whether the finding is consistent with the hypothesis. The output includes an effect size (r) for each study in the sample, as well as an overall Zr and r for the entire sample.

For studies providing F(1), t, r, $X^2(1)$ or an exact p value, this statistic was input into the program. For studies reporting a test statistic and estimated p, Rosenthal and Rosnow's (1984) extended tables were used to determine an exact, one-tailed p value. In some cases the exact p value had to be interpolated. For samples reporting an F test with more than one degree of

freedom and standard deviations, t tests were computed using Rosenthal and Rosnow's (1985) formula. In all cases, the highest order test available was used in the meta-analysis (i.e., an interaction test or post hoc analyses were included rather than an omnibus test wherever possible). For samples reporting other statistics, an r, t or $X^2(1)$ value was computed from available data. If insufficient data was reported p values and the associated degrees of freedom were used to calculate t. When a significant result was reported without data, test or p value, p was set at .025 (one-tailed). Generally, p values are reported only when results were significant. Unavailable, non-significant p values were set at .500 (one-tailed). Two-tailed p values for results inconsistent with hypotheses were halved and subtracted from 1.00. All of the above estimation techniques provide conservative estimates and have been recommended by Mullen and Rosenthal (1985).

Meta-analytic techniques are designed for independent measures. When a study reports numerous measurements of a particular phenomenon, the inherent covariance results in an inflated mean r. Strube (1983) has developed a formula to adjust for covariance; however, insufficient data was available from the sample to use this formula. An alternative solution, used here, is to combine the measures within each study (Mullen & Rosenthal, 1985).

All effect sizes were weighted for sample size. While some meta-analysts weight by the quality of a study (internal and external validity), there is a danger in weighting higher the results that are favored. In addition, Glass has provided

evidence that there is no strong relationship between quality of study and average effect size obtained (Rosenthal, 1984).

Published studies represent only a portion of the work carried out in any field. Many other unpublished studies likely exist in "filedrawers" (Rosenthal, 1978). Mullen and Rosenthal's (1985) computer program for combining probability levels gives a failsafe number--the number of null findings it would take to reduce the p value associated with the combined effect size to .Ø5. Rosenthal and Rosnow (1985) have devised an equation which estimates the number of unpublished studies which may exist: 5k + 1Ø, where k = number of retrieved studies. This so-called tolerance level indicates whether the meta-analytic finding is resistant to the filedrawer problem.

Before combining the results of independent research and drawing conclusions from those results, Rosenthal and Rosnow (1985) suggest testing for heterogeneity of effect sizes. Significant heterogeneity indicates that the sample studies do not come from the same population (Rosenthal & Rosnow, 1985) and suggest the influence of a moderator variable(s) (Strube, 1985). Thus, performing a meta-analysis on that particular body of data would be inappropriate and misleading and the total sample should be subdivided in some logical manner.

The specific questions addressed by these meta-analyses are as follows:

1. Is there a relationship between play and fluency?

2. Is there a relationship between play and originality?

3. Is there a relationship between play and problem solving ability?

Table 1. Fluency Studies[a]

Study	n	Age	Sessions	IV	Tests & Means	DV	Results	z	r	p[b/d]
Sutton-Smith 1968	18	6	1	1) male (M) 2) female (F)	AUT w/ male toys (block, truck) & female toys (doll, dish 1 2 M toys 17.2 7.1 F toys 7.0 10.2	Fluency	F toys 1 = 2 M toys 1 > 2	1.59 2.37	.37 .55	.070 .010
Goodnow, 1969	128	5	1	1) look 2) look & handle	AUT w/ kleenex (K), paperclip (P) & screwdriver (S) 1 2 K 1.4 1.0 P 1.3 1.3 S 1.7 1.6	Fluency w/ unfamiliar items	K: 1 > 2 P: 1 = 2 S: 1 = 2	-1.96 .00 .00	-.15 .00 .00	.075 .500 .500
Dansky & Silverman, 1973	90	3-5	1:10 min.	1) free play 2) imitation 3) control	AUT w/ papertowel, screwdriver, paperclip & matchbox[c]	Fluency w/ familiar	1 = 2 1 = 3	.00 .00	.00 .00	.500 .500
Dansky & Silverman, 1975	36	4	1:10 min.	1) free play 2) imitation 3) intellect	AUT w/ papertowel, plastic cup & coathanger[c]	Fluency w/ unfamiliar	1 > 2 1 > 3	1.64 1.64	.34 .34	.025 .025
Johnson, 1976	63	3-5	10:5 min.	1) social pretend play 2) non-social pretend play	AUT and story completion[c]	Correlations: Social & story fluency common uses uses fluency Non-social & story fluency common uses uses fluency	 n/a n/a n/a n/a n/a n/a	 2.81 .94 3.16 .62 .86 1.17	 .35 .12 .39 .08 .11 .15	 .005 .500 .005 .500 .500 .500

Li, 1978	120	5	1:10 min.	1) pretend 2) free play 3) imitation 4) control	AUT w/ papertowel (P), matchbox (M), paperclip (C) & screwdriver (S)	Fluency w/ familiar & unfamiliar	P: 1=2=3=4 M: 1=2=3=4 C: 1=2=3=4 S: 1=2=3=4	.00 .00 .00 .00	.00 .00 .00 .00	.500 .500 .500 .500
Pellegrini 1981	36	3-5	1:10 min.	1) free play 2) questions 3) control	AUT w/ 3x5" card, papertowel, clotheshanger	Fluency w/ unfamiliar	1 = 2 1 = 3	.00 .00	.00 .00	.500 .500
Pepler & Ross 1981 Expt. I	64	3-4	3:10 min.	1) divergent play 2) convergent play 3) divergent observe 4) convergent	Puzzles 1 2 3 4 11.5 7.5 6.44 7.97	Fluency on 2 divergent tasks	1 & 3 > 2 & 4 1 & 2 = 3 & 4	2.18 .00	.31 .00	.015 .500
Expt. II	72	3-4	3:10 min.	1) same 2) same 3) control	Puzzles	Fluency on 2 divergent tasks	1 = 2 1 = 3	.00 .00	.00 .00	.500 .500
Christie, 1983	17	3-4	9:20 min.	1) play tutoring 2) skill training	Torrance Thinking Creatively in Action 1 2 Immed. 114.3 121.3 Delay 117.1 121.6	Fluency	Immediate: 1 = 2 Delayed: 1 = 2	.00 .00	.00 .00	.500 .500
Smith & Whitney, 1987	64	4	1:10 min.	1) pretend 2) free play 3) imitation 4) control	AUT w/ familiar (cotton reel, clothespin, pipe-cleaner, plastic cup) & unfamiliar items (coat hanger, plastic cup, tea strainer)	Fluency: Familiar Unfamiliar	1=2=3=4 1=2=3=4	.00 .00	.00 .00	.500 .500

a Statistics listed in tables are not necessarily those reported in journal
b one-tailed
c not reported in original article
d estimated values

Table 2. Originality Studies[a]

Study	n	Age	Sessions	IV	Tests & Means	DV	Results	z	r	p[b]
Sutton-Smith 1968	18	6	1	1) male (M) 2) female (F)	AUT w/ male toys (block, truck) & female toys (doll, dish) 1 2 M toys 10.7 2.4 F toys 2.8 4.7	Novel uses	F toys: 1 = 2 M toys: 1 > 2	1.03 2.06	.26 .49	.500 .025
Goodnow, 1969	128	5	1	1) look 2) look & handle	AUT w/ kleenex (K), paperclip (P) & screwdriver (S)[c] 1 2 K 1.6 2.4 P 1.3 2.0 S 1.4 2.0	Novel uses w/ unfamiliar items	K: 1 < 2 P: 1 < 2 S: 1 < 2	2.59 2.59 2.59	.23 .23 .23	.005 .005 .005
Hutt & Bhavnani, 1972	48	7-10	1	1) nonplayers 2) explorers 3) inventive explorers	Wallach & Kogan battery 1 2 3 Male 24.5 44.9 76.3 Female 36.2 39.8 61.5	Originality Originality correlated w/ play	Males: 1 < 2 1 < 3 Females: 1 = 2 1 < 3 Males Females	3.63 2.23 .52 2.36 2.52 1.81	.73 .51 .12 .64 .52 .37	.001 .010 .500 .010 .010 .075
Feitelson & Ross, 1973	24	5	10:30 min	1) play tutoring 2) free play 3) music tutoring 4) control	Dog & Bone; Torrance Thinking Creatively with Pictures test Inno Orig Flex 1 4.33 4.20 0.83 2 1.83 -0.30 0.33 3 0.83 1.00 0.50 4 3.66 1.50 1.15	Innovation Originality Flexibility	1=2=3=4 1>2=3=4 1=2=3=4	1.65 1.96 .00	.34 .40 .00	.050 .025 .500
Dansky & Silverman, 1973	90	3-5	1:10 mins	1) free play 2) imitation 3) control	AUT w/ papertowel (P), screwdriver (S), paperclip (C), matchbox (M) 1 2 3 P 6.25 2.50 2.40 S 2.75 0.75 0.75 C 5.25 1.00 1.50 M 5.50 1.60 1.50	Novel uses w/ familiar items	1 > 2 1 > 3	2.82 2.82	.52 .52	.005 .005
Dansky & Silverman, 1975	36	3-5	1:10 mins	1) free play 2) imitation 3) control	AUT w/ papertowel, coat hanger, plastic cup & screwdriver	Novel uses w/ familiar items	1 > 2 1 > 3	2.82 2.82	.52 .52	.005 .005

Johnson, 1976	63	3-5	10:5 mins	1) social pretend play 2) non-social pretend play	Uses task; story completion task	Correlations: social play & fantasy uses	n/a	4.37	.52	.001
						non-social & fantasy uses	n/a	.78	.10	.500
Li, 1978	120	5	1:10 mins	1) pretend 2) free play 3) imitation 4) control	AUT w/ papertowel (P), matchbox (M), paperclip (C) & screwdriver (S) P: 1=3.06, 2=3.50, 3=2.26, 4=2.80 M: 1=2.63, 2=2.36, 3=1.93, 4=1.80 C: 1=1.93, 2=2.30, 3=1.16, 4=0.90 S: 1=1.53, 2=0.43, 3=1.03, 4=0.73	Novel uses w/ familiar & unfamiliar items	P: 1=2=3=4	.10	.01	.500
								1.80	.17	.500
								.59	.05	.500
								2.77	.25	.500
								1.59	.15	.500
							M: 1=2=3=4	.67	.06	.500
								1.73	.16	.500
								2.06	.19	.500
								1.07	.10	.500
								1.39	.13	.500
							C: 1=2=3=4	2.79	.25	.030
								3.07	.28	.040
								3.74	.34	.010
								1.02	.09	.500
								2.10	.19	.500
							S: 1=2=3=4	3.43	.31	.010
								2.52	.23	.050
								1.59	.15	.500
								1.90	.18	.500
								.96	.09	.500
Smith & Syddall, 1978	14	3-4	15:40 min	1) play training 2) skill training	Dog & Bone test	Innovation	1 = 2	.93	.27	.500
Smith, Dalgleish & Herzmark, 1981	77	3-4	32:40 min	1) play training 2) skill training	Dog & Bone test Immediate: School A: 1=3.05, 2=2.95; School B: 1=3.53, 2=3.22 Delayed: School A: 1=3.19, 2=3.43; School B: 1=4.19, 2=3.77	Innovation	Immediate: 1=2			
							School A	.67	.11	.500
							School B	.14	.02	.500
							Delayed: 1=2			
							School A	.74	.14	.500
							School B	.14	.02	.500
Pellegrini, 1981	36	3-5	1:10 mins	1) free play 2) questions 3) control	AUT w/ 3x5" cards, papertowel, clothes hanger 1=4.00, 2=8.75, 3=2.25	Novel uses w/ unfamiliar items	2 > 1	-1.96	-.40	.075
							1 = 3	.00	.00	.500

Pepler & Ross, 1981 Expt. 1	64	3-4	3:10 mins	1) divergent play 2) convergent play 3) divergent observe 4) convergent observe	Puzzles 1 2 3 4 3.41 1.47 0.75 1.22	Originality on 2 divergent tasks	1 & 3 > 2 & 4 1 & 2 > 3 & 4	1.72 3.15	.31 .43	.015 .001
Expt. 2	72	3-4	3:10 mins	1) same 2) same 3) control	Puzzles & AUT [c]	Originality	1 > 2 1 > 3	2.03 2.19	.29 .32	.025 .025
Christie, 1983	17	3-4	9:20 mins	1) play training 2) skill training	Torrance Thinking Creatively in Action test [c]	Originality	Immediate: 1=2 Delayed: 1=2	.95 .00	.25 .00	.150 .500
Smith & Whitney, 1987	64	4	1:10 mins	1) pretend 2) free play 3) imitation 4) control	AUT w/ clothespin, cotton reel, pipecleaner, plastic cup or coat hanger, tea strainer [c]	Novel uses w/ familiar & unfamiliar items	Familiar: 1=2=3=4 Unfamiliar: 1=2=3=4	.00 1.04	.00 .13	.500 .150
Dansky, 1980 Expt. 1	96	4	1:10 mins	1) free play 2) imitation 3) convergent problem solve Each group is subdivided into players (P) & non-players (NP)	AUT w/ papertowel, cup, screwdriver, clothes hanger [c]	Uses w/ unfamiliar items	1P > 1NP = 2P = 2NP = 3P = 3NP	5.14 4.74 5.61 4.94	.77 .73 .81 .75	.001 .001 .001 .001
Expt. 2	16	5	1:10 mins	1) free play 2) imitation 3) control	same [c]	same	1 > 2 > 3	1.91	.62	.025

a Statistics listed in tables are not necessarily those reported in journal
b one-tailed
c not reported in original article
d estimated values
e estimated from graph

Table 3. Problem Solving Studies[a]

Study	n	Age	Sessions	IV	Tests & Means	DV	Results	z	r	p[b/d]
Rosen, 1974	58	5	40:60 min 10:60 min	1) play training 2) skill training	Torrance Group Construction Task[c]	# blocks per building	1 > 2	2.90	.74	.005
						productive behaviors	1 > 2	2.00	.56	.025
						performance	1 > 2	3.61	.84	.0005
Sylva, Bruner & Genova, 1976	108	3-5	1:10 min 1:08 min 1:01 min	1) free play 2) observe 3) control	Lure retrieval w/ sticks & clamps 1 2 3 SS 14 15 3 Acts 1.72 0.86 0.92	spontaneous solvers	1 > 3	3.05	.36	.0025
							1 = 2	.00	.00	.500
Expt. 1						# hints	1 > 2	2.58	.30	.005
						# goal-directed acts	1 > 2	2.58	.58	.005
							1 > 3	2.58	.58	.005
Expt. 2	108	3-5	1:10 min	1) free play 2) observe 3) training	Lure retrieval 1 2 3 SS 14 6 7	spontaneous solvers	1 > 2	1.96	.23	.025
							1 > 3	1.96	.23	.025
						configurational richness	1 & 2	4.50	.67	.0005
							1 & 3	4.49	.67	.0005
Smith & Dutton 1979	108	4	1:08 min	1) free play 2) training 3) control 1 4) control 2	Lure retrieval w/ sticks & blocks (Task 1 = 2-stick & Task 2 = 3-stick) Task 1: ST H SS 1 3.44 1.92 12 2 3.58 2.25 7 3 5.13 3.78 2 Task 2: ST H SS 1 1.70 0.42 25 2 3.98 2.03 8 3 6.53 4.22 -- 4 7.75 4.67 3* * 3 & 4 combined	Task 1: solution time	1 = 2	1.53	.16	.060
							1 > 3	4.31	.44	.001
						# hints	1 = 2	1.10	.12	.150
							1 > 3	4.78	.48	.001
						spontaneous solvers	1 = 2	1.34	.16	.200
							1 & 2 = 3	1.37	.16	.200
						Task 2: solution time	1 > 2	6.78	.60	.001
							1 > 3	10.11	.79	.001
							1 > 4	11.57	.85	.001
						# hints	1 > 2	5.45	.50	.001
							1 > 3	9.13	.74	.001
							1 > 4	9.85	.78	.001
						spontaneous solvers	1 > 2	4.01	.47	.001
							1 > 3 & 4	4.16	.49	.001
Vandenberg 1981	90	4-10	1:10 min	1) free play 2) questions	Lure retrieval w/ sticks & pipecleaners (Task 1 = 2-stick & Task 2 = 1-stick) Task 1: 1 2 hint 14.6 10.7 SS 15 9 acts 29.2 33.4	Task 1: hint score	1 > 2	2.43	.36	.007
						spontaneous solvers	1 = 2	.00	.00	.500
						goal-directed acts	1 > 2	1.96	.21	.025
						configurational richness		1.66	.25	.050

					Task 2: 1 2 hint 8.3 7.8 SS 24 21 acts 16.2 20.8	Task 2: hint score spontaneous solvers acts conf. rich.	1 = 2 1 = 2 1 = 2	.00 .00 .00 .00	.00 .00 .00 .00	.500 .500 .500 .500
Pepler & Ross 1981 Expt. 1	64	3-4	3:10 min	1) divergent play 2) convergent play 3) divergent observe 4) convergent observe	Puzzles[c]	Fluency	1 & 3 = 2 & 4	.00	.00	.500
Expt. 2	72	3-4	3:10 min	1) same 2) same	Puzzles[c]	Strategy moves # runs	1 > 2 1 > 2	2.04 2.43	.29 .34	.040 .020
Cheyne & Rubin 1983	140	4	1:08 min	correlational study	Lure retrieval w/ sticks & blocks[c]	Solution time and: use of principle conf. rich.		3.23 3.48	-.27 -.29	.0005 .0005
Simon & Smith 1983	64	4	1:08 min	1a) free play 1b) free play 2a) training 2b) training a = unaware b = aware	Lure retrieval w/ sticks & blocks (Task 1 = 2-stick & Task 2 = 3-stick) Task 1: ST H SS 1 224.9 7.8 8* 2 308.4 5.7 -- 3 306.8 9.8 3* 4 193.3 5.3 -- Task 2: 1 99.9 2.9 20* 2 105.7 4.1 -- 3 125.3 6.4 14** 4 102.4 4.0 -- * 1 & 2 combined ** 3 & 4 combined	Task 1: hint score spontaneous solvers Task 2: hint score spontaneous solvers Tasks 1 & 2: solution time	1 & 2 = 3 & 4 1 & 2 = 3 & 4 1 & 2 = 3 & 4 1 & 2 = 3 & 4 1 & 2 = 3 & 4	.00 .00 .00 1.25 .12	.00 .00 .00 .16 .02	.500 .500 .500 .200 .500

Table 3, p. 3

Smith, Simon & Emberton, 1984	40	4	1:08 min	1) free play 2) training	Lure retrieval w/ sticks & blocks (Task 1 = 2-stick & Task 2 = 3-stick) Task 2: 1 2 ST 240.5 190.0 hint 1.45 1.15 score 9.15 6.75	Task 1: solution time # hints hint score Task 2: solution time # hints hint score	1 = 2 1 = 2 1 = 2 1 = 2 1 = 2 1 = 2	.84 .84 .84 -.84 -.84 -.84	.20 .20 .20 -.20 -.20 -.20	.500 .500 .500 .500 .500 .500
Simon & Smith 1985	80	4	1:08 min	1) free play 2) training 3) questions 4) control	Lure retrieval w/ sticks & blocks (Task 1 = 2-stick & Task 2 = 3-stick) Task 1: ST H SS 1 253.3 1.65 0 2 250.0 1.90 4 3 270.9 2.05 1 4 223.4 1.60 4 Task 2: 1 197.9 1.00 7 2 153.3 0.65 12 3 210.6 1.05 7 4 163.7 0.65 11	Task 1: solution time # hints spontaneous solvers	1=2=3=4 1=2=3=4 1=2=3=4	.84 .00 .00 .13 .21 .03 .00	.12 .00 .00 .02 .05 .00 .00	.200 .500 .500 .500 .500 .500 .500

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b one-tailed
c not reported in original article
d estimated values

Table 4

Play and Fluency: Effect Sizes and Significance Levels Within Studies

Study	Mean Effect Size	Mean Z
Sutton-Smith, 1967 (UF)	.46	.50
Goodnow, 1969 (U)	.04	.04
Dansky & Silverman, 1973 (F)	.00	.00
Dansky & Silverman, 1975 (U)	.40	.43
Johnson, 1976 (U)	.20	.21
Li, 1978 (F)	.00	.00
Pellegrini, 1981 (F)	.00	.00
Pepler & Ross, 1981 (F)		
(I)	.08	.08
(II)	.00	.00
Christie, 1983 (U)	.00	.00
Smith & Whitney, 1987 (UF)	.00	.00

F = familiarity of objects (study included in familiarity sample for meta-analysis)
U = unfamiliarity of objects (study included in unfamiliarity sample for meta-analysis)

Table 5. Play and Originality: Effect Sizes and Significance Levels Within Studies

Study	Mean Effect Size	Mean Z
Sutton-Smith, 1967 (UF)	.38	.40
Goodnow, 1969 (U)	.20	.21
Hutt & Bhavnani, 1972 (U)	.50	.56
Feitelson & Ross, 1973 (UF)	.25	.26
(F)	.34	.35
(U)	.21	.21
Dansky & Silverman, 1973 (F)	.36	.37
Dansky & Silverman, 1975 (U)	.52	.57
Li, 1978 (F)	.16	.16
Smith & Syddall, 1978 (F)	.27	.93
Dansky, 1980 II (U)	.62	.72
Pepler & Ross, 1981 (divergent tasks)		
I (F)	.37	.39
II (F)	.31	.32
Pellegrini 1 (F)	-.14	-.14
Smith, Daly & Herzmark, 1981 (F)	.08	.08
Christie, 1983 (U)	.00	.00
Dansky, 1986	.12	.12
Smith & Whitney, 1987 (UF)	.00	.00
		p
Johnson, 1976 (U)	Z = 2.61	.005
Li, 1978 (UF)	X^2 = 37.76	.006
Dansky, 1980 I (U)	X^2 = 112.86	.0000001

F = familiarity of objects (included in familiarity sample for meta-analysis)
U = unfamiliarity of objects (included in unfamiliarity sample for meta-analysis)

Table 6. Play and Problem-Solving: Effect Sizes and Significance Levels Within Studies

Study	Mean Effect Size	Mean Z
Rosen, 1974	.73	.93
Cheyne & Rubin, 1983	.28	.29
Simon & Smith, 1983	.05	.05
Smith, Simon & Emberton, 1984	-.20	-.21
Simon & Smith, 1985	.04	.04
Pepler & Ross, 1981 (convergent tasks)		
I&II	.12	.12
I	.00	.00
II	.32	.33
	Chi Square	p
Sylva, Bruner & Genova, 1976	X = 40.28	.000002
Smith & Dutton, 1979	X = 166.34	.0000001
Vandenberg, 1981	X = 14.78	.09

Table 7. Meta-Analytic Results

META-ANALYTIC RESULTS

Analysis	Combined r	p	Filedrawer #
Fluency	.06	.16	n/a
Familiarity	.03	.33	n/a
Unfamiliarity	.05	.26	n/a
Originality	X = 42.02,	p = .0002	
Unfamiliarity	X = 31.26,	p = .0001	
Familiarity	.22	.0000005	66
Problem-Solving	X = 70.67,	p < .0000001	
Solution time	.11	.005	1
Spontaneous solvers	.11	.04	1